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TABLE E — ILLUSTRATION OF METHOD OF SECURING INDICES OF SEASONAL VARIATION FROM MEDIANS OF MONTH-TO-MONTH LINK RELATIVES *

PIG-IRON PRODUCTION

	$\frac{\text{Jan.}}{\text{Dec.}}$	$\frac{\text{Feb.}}{\text{Jan.}}$	$\frac{\text{Mar.}}{\text{Feb.}}$	$\frac{\text{Apr.}}{\text{Mar.}}$	$\frac{\text{May}}{\text{Apr.}}$	$\frac{\text{June}}{\text{May}}$	$\frac{\text{July}}{\text{June}}$	$\frac{\text{Aug.}}{\text{July}}$	$\frac{\text{Sept.}}{\text{Aug.}}$	$\frac{\text{Oct.}}{\text{Sept.}}$	$\frac{\text{Nov.}}{\text{Oct.}}$	$\frac{\text{Dec.}}{\text{Nov.}}$	$\frac{\text{Jan.}}{\text{Dec.}}$
Medians of Link Relatives.......	100.0	96.0	114.0	98.0	102.5	95.0	100.0	103.0	101.0	107.5	96.0	102.0	100.0

CHAIN SERIES	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
With January as 100	100.0	96.0	109.4	107.2	109.9	104.4	104.4	107.6	108.6	116.8	112.1	114.3	114.3
Adjusted for Discrepancy †	100.0	95.0	107.0	103.7	105.1	98.8	97.7	99.5	99.3	105.6	100.2	101.1	100.0
With Arithmetic Average as 100 ‡.	98.9	93.9	105.9	102.6	104.0	97.7	96.6	98.4	98.3	104.5	99.2	100.0	98.9

* Although computations are carried to tenths of a per cent, the original figures and the results are not accurate beyond the units place.

† Adjusted by dividing previous chain series by $(1.011)^{n-1}$ where n is the number of the month and $(1.011)^{12} = 1.143$.

‡ Change to new base secured by dividing previous series by arithmetic average of that series.

production there is a strong upward secular trend; in interest rates a slight downward trend (see Charts 2 and 13.) The discrepancies correspond precisely to these secular trends. In order that the chain relatives may measure seasonal variation only the discrepancy due to secular trend should be distributed; the seasonal relatives should be adjusted to allow for such discrepancy.

The " adjusted monthly indices of seasonal variation " given in Tables 1 to 15 are the original medians of the month-to-month relatives, (1) expressed as a chain series with January as the base, (2) adjusted so that the discrepancy between consecutive January relatives is zero, and (3) changed proportionally so that the arithmetic average of the twelve indices is 100. The effect that the last two operations have upon the chain series of medians is shown graphically for interest rates on four-to-six months paper and pig-iron production in Charts G and H. The graphs with the solid black points represent the adjusted monthly indices of seasonal variation. In these charts the 100 per cent line represents January for two of the graphs and the average for the year in the third. Table E shows the steps in adjusting the indices for pig-iron production.[1] The indices are presented graphically in the inserts of Charts 1 to 15 and these charts are preceded by a summary discussion of seasonal variation for each series.

The reason for expressing the seasonal indices in terms of a fixed base (January or the average for the year) is to secure indices of seasonal variation which may be applied as corrective factors to a continuous series. The items of the original continuous series should be corrected not with respect to the month preceding but with respect to all the months of the year.

That the method of measuring seasonal variation just developed gives consistent results for similar series is evident from Chart K. That chart presents the graphs of the adjusted indices of seasonal variation for the yield on ten railroad bonds, the rate on four-to-six months commercial paper, the rate on sixty-to-ninety days commercial paper, and the rate on call loans at the New York Stock Exchange. In all cases the graphs are of the same general shape but the *extent* of the fluctuations varies greatly. The graphs for the two series most alike — the rates on commercial paper — are most similar both in shape and amplitude. The seasonal (?) variation in the yield of bonds is, of course, minute, in comparison with the call rate. All of the results are in the nature of confirmatory evidence of the reliability of the method developed.

Of the four types of fluctuations which, as has been explained, together make up any series of economic data in its original state, we have now developed methods for measuring two, secular trend and seasonal variation. There remain to be considered the cyclical and irregular fluctuations. Is it possible to measure the element in the original series which is due to the cycle of business prosperity and depression ?

4. MEASUREMENT OF CYCLICAL AND IRREGULAR FLUCTUATIONS

By the term " cyclical fluctuations " is meant that movement of the data which occurs at times of industrial activity or of industrial depression. The movement is called " cyclical " in accordance with accepted terminology. No assumption of fixity or regularity of the cycles is involved in the present use of the term. The requisite is that in order to be cyclical, a succession of large items must be followed by a succession of smaller items, or *vice versa.*

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[1] The method of adjusting the chain indices with January as the base is as follows. (1) To adjust the discrepancy between consecutive Januarys: Let $c_1, c_2, c_3 \ldots, c_{12}$ represent the chain relatives obtained by progressive multiplication of the medians of the link relatives $r_1, r_2, \ldots, r_{11}, r_{12}$. Since January is the base $c_1 = 100$, the product $100 \cdot r_1\, c_{12}$ will not, in general, give 100 but something in excess or defect of 100, depending on the direction of the secular trend of the data. The discrepancy between successive January chain relatives is $100 r_1\, c_{12} \div 100$, or $r_1\, c_{12}$. This discrepancy, due primarily to secular trend, is distributed according to the compound interest law among the chain relatives. Letting the percentage discrepancy for one month be d we have $(1 + d)^{12} = r_1\, c_{12}$. Solve for d by the use of logarithms. Then, by logarithms, find the values of:

$$100, \quad \frac{c_2}{1 + d}, \quad \frac{c_5}{(1 + d)^2}, \quad \ldots, \quad \frac{c_{12}}{(1 + d)^{11}},$$

which is the chain series adjusted for the discrepancy. Distribution of the discrepancy on the assumption that it is a uniform monthly increment does not give significantly different results. (2) To change from January as the base to the arithmetic average of the year as the base: Divide each item of the adjusted chain series by the arithmetic average of such chain series for the year.

CHART K

COMPARISON OF THE SEASONAL VARIATIONS OF

○---○---The average yield of ten railroad bonds

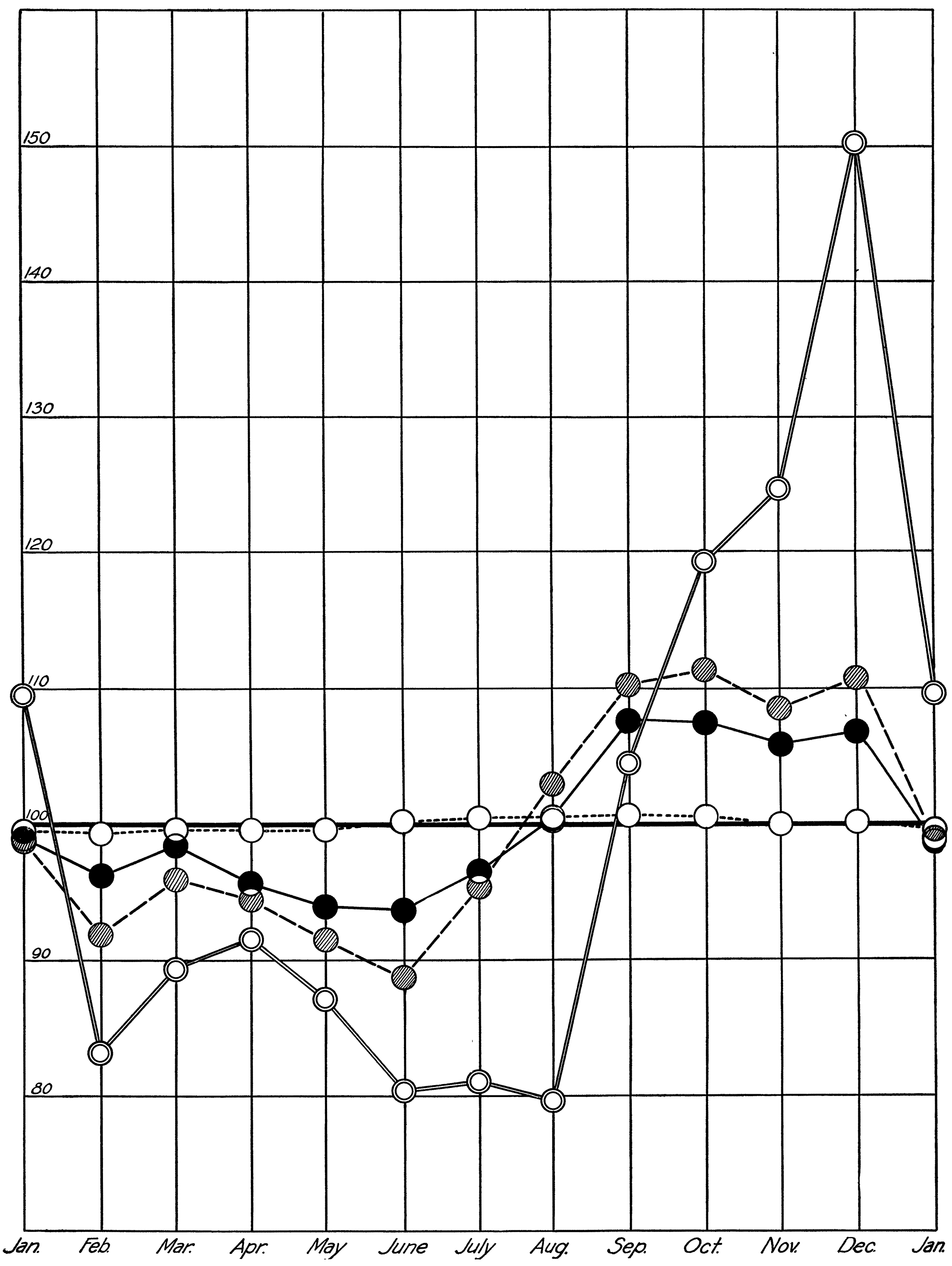
●—●—The rate on four to six months commercial paper

▨--▨—The rate on sixty to ninety days commercial paper

◎=◎=The rate on call loans on the New York Stock Exchange

As shown by the

Adjusted Monthly Indices of Seasonal Variation   Average for year = 100



The concept of "irregular or residual fluctuations" also requires definition. Such fluctuations may be isolated or they may occur in succession. In either case they are distinguished by this fact: it is possible to relate large fluctuations to definitely assigned causes. Thus, pig-iron production may take a sudden slump if a strike occurs; railway gross earnings may drop because of unusual storms or floods; trading on the stock exchange may be greatly affected by a court decision. The contributing cause, however, may be so momentous as to have a widespread and lasting effect on numerous series. Thus the Great War affected industry in the United States in 1914–16, at least to as great a degree as the series of events leading to the crisis of 1907 affected industry in 1906–08. Insofar as the statistical data themselves go, it is impossible to distinguish between such "irregular" movements and cyclical fluctuations.[1] Moreover, isolated irregular fluctuations may be large fluctuations occurring in a crisis as phenomena of the business cycle.[2] No distinction, therefore, between "cyclical" and "irregular" fluctuations may be obtained simply by study of statistical data. Interpretation of the fluctuations in the light of contemporaneous economic events is necessary.

It may seem to the reader that a distinction between "cyclical" and "irregular" fluctuations has been made merely to be discarded. It is true that there is, apparently, no general method of ear-marking those portions of the compound assignable to each of the two types of fluctuations. The statistical data themselves, nevertheless, offer much evidence in support of the realistic character of the concepts described. The assumption that there is a cyclical movement in series of fundamental statistics few will controvert. The ebb and flow of business by a process of gradual change constitutes the business cycle. The gradualness of the process, however, may be interrupted. If these interruptions are important, it may be worth while to search for the explanation. Certain interruptions may be so momentous as to halt the cyclical movement in progress and substitute another in its place. It is to these interruptions, whether large or small, that we have given the name "irregular fluctuations." In the present state of economic inquiry, however, it does not appear profitable to press further the distinction between irregular and cyclical fluctuations.

Notwithstanding the existence of irregularities it is generally recognized that there *is* a persistent rhythmic, or wave-like, or cyclical movement in series of fundamental statistics. The existence of ebb and flow in the magnitudes is revealed by the simple device of taking twelve months moving averages. The curves located by such averages are shown in Charts 1 to 15. The process of computing the averages and locating the curves is as follows: the items of each series were averaged arithmetically for calendar years beginning with consecutive months, such as January to December, 1903; February 1903 to January 1904; March 1903 to February 1904, and so on to the end of the period under examination. The averages thus obtained determine ordinates on the charts in the middle of the twelve months averaged. These ordinates fix points which locate the undulating curves.

The process of taking twelve months moving averages eliminates seasonal variation, for each average depends upon the items for a year. In addition, the process distributes throughout the year isolated irregularities occurring in individual items. It preserves, however, the secular trend and any rhythmic fluctuations extending over a number of items. By taking deviations of the undulating curve from the line of secular trend we have some indication of the fundamental nature of cyclical fluctuations. Chart J presents these deviations for eight series, the deviations being expressed as percentages of the corresponding ordinates of secular trend. It is clear that the undulations are not unrelated. However, these deviations may not, properly, be used to measure the cyclical movement. The maxima and minima of the curve of averages are, of course, less pronounced than those of the original series. In addition, such maxima and minima do not occur simultaneously with those of the original series, but precede the latter by an interval depending on the violence of the fluctuations of the items. Finally, the curve of averages begins half a year after the original series and ends half a year before the latter.

If the twelve months moving average may not be used to measure cyclical fluctuation how may a measure be obtained? The sort of measure desired is one that is not applicable merely to past data but that can be applied with some confidence to the present and future. Is there a "law" of business cycles which holds so consistently over a considerable period of the past that we may reasonably expect it to hold in the future? Are business cycles systematic and periodic?

The first obstacle encountered in an investigation of periodicity of business cycles is the lack of data covering a wide interval of time. The period since 1890, or even since 1860, is not of sufficient length for the study of the periodicity of crises and depressions. A longer period introduces a new difficulty, the heterogeneity of industrial and business conditions in widely separated years. Every student of industrial history recognizes that the conditions in the first half of the nineteenth century were widely different from those in the second half. Even should the evidence available point to periodicity, therefore, the assertion of a "law" of cycles would scarcely be warranted. In fact, however, the available evidence does not square with the hypothesis that crises are periodic. In the United States there were major crises in 1873, 1893, and 1907; there were minor crises in 1884 and 1903; there was the free silver panic of 1896, and there was the war crisis of 1914, followed by depression and then activity. In connection with all of these disturbances there were rhythmic

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[1] Thorstein Veblen's theory is that periods of prosperity are always traceable to the stimulus of some "favorable disturbance of the course of business." See *Theory of Business Enterprise*, p. 194. But see p. 183.

[2] *Infra*, p. 26.

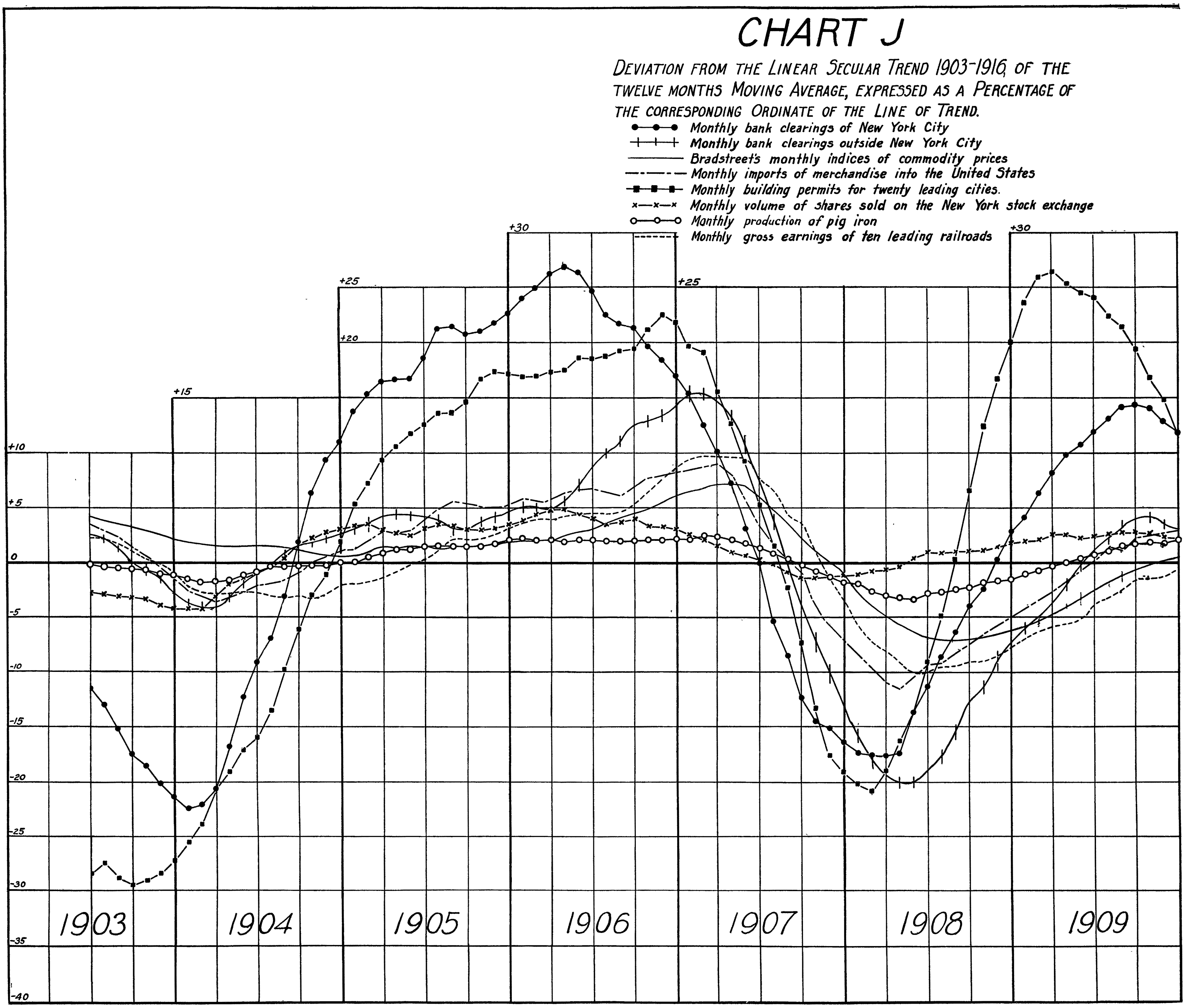


CHART J

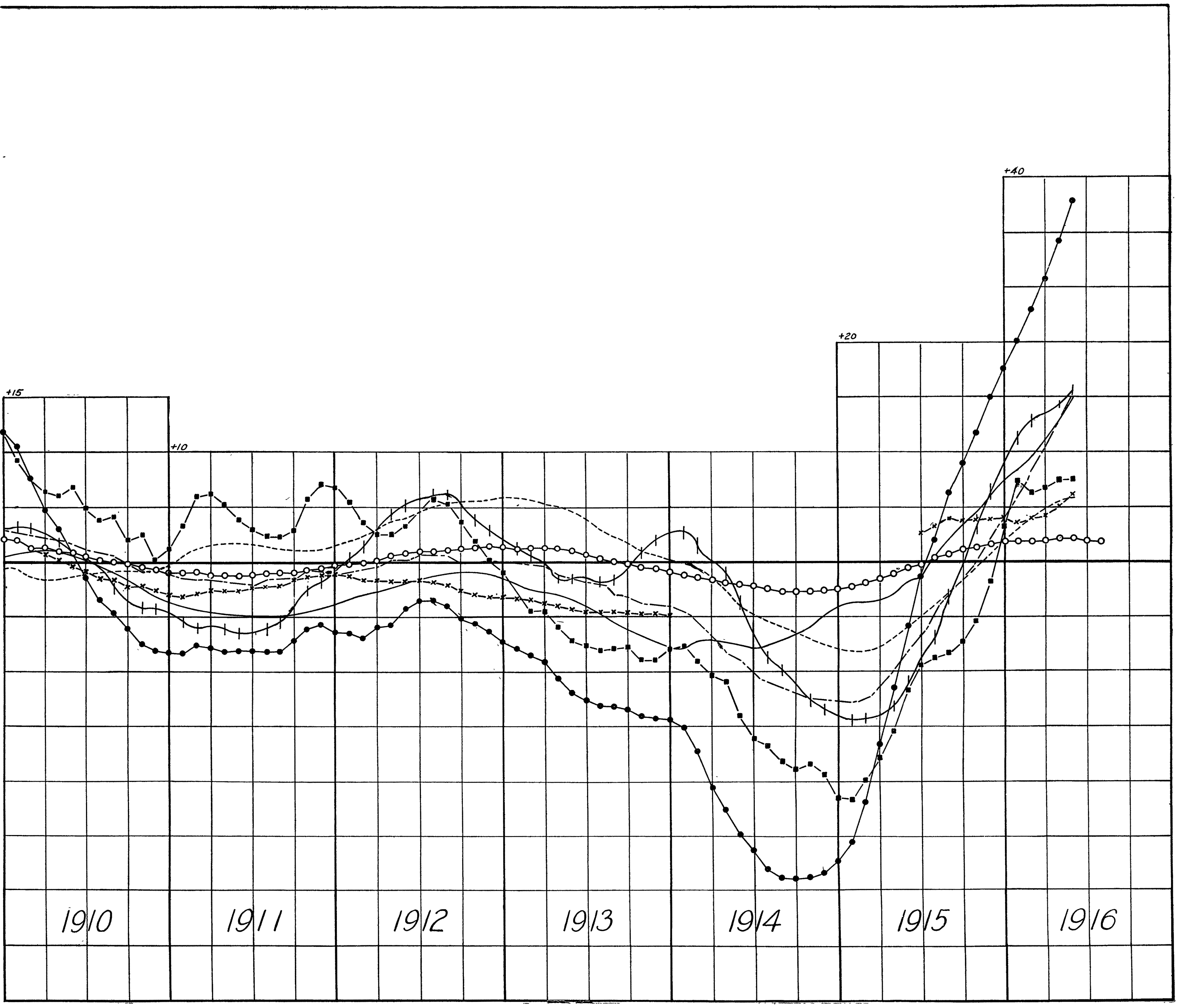
DEVIATION FROM THE LINEAR SECULAR TREND 1903-1916, OF THE TWELVE MONTHS MOVING AVERAGE, EXPRESSED AS A PERCENTAGE OF THE CORRESPONDING ORDINATE OF THE LINE OF TREND.

movements in all series of fundamental statistics. But the waves in different series were of varying amplitudes at a given time, and those of a given series varied in amplitude and length at different times. This is the nature of the evidence at our disposal upon which to base a conclusion concerning periodicity of business cycles. If there be a period, is it four or ten or twenty years long? W. S. Jevons formulated the hypothesis that periods of business cycles correspond with periods of sun spots.[1] H. S. Jevons, in supporting the theory that periodicity depends on meteorological conditions, contends that there is a three and a half year period in wheat production.[2] The dates of crises in the nineteenth century have been used to support the contention that crises are approximately ten years apart, major and minor disturbances alternating. Are there major and minor crises? Is there one sort of periodicity for crops and pig-iron production and another sort for prices and building? The writers on business cycles have discovered neither general nor special laws from which we are warranted in postulating that business cycles occur regularly or systematically or periodically. Although there is conclusive evidence for the rhythmic movement of economic phenomena, there is but slender support for the theory of periodicity. In *Les Crises Periodiques de Surproduction* (1913), by Albert Aftalion, the author uses the phrase "periodic oscillations" to indicate a rhythmical movement, more or less irregular in character.[3] Neither Wesley C. Mitchell in *Business Cycles* (1914) nor D. H. Robertson in *A Study of Industrial Fluctuation* (1915) maintains that business cycles are periodic. The most elaborate argument for periodicity has been presented by Professor Henry L. Moore in *Economic Cycles: Their Law and Cause* (1914). Professor Moore contends that weather conditions in the United States "pass through cycles of approximately

[1] See *Investigation in Currency and Finance.*

[2] See *Causes of Unemployment*, p. 74.

[3] See vol. i, chap. 1.



thirty-three years and eight years in duration, causing like cycles in the yield per acre of the crops; these cycles of crops constitute the natural, material current which drags upon its surface the lagging, rhythmically changing values and prices with which the economist is more immediately concerned." (p. 149.) This conclusion is based upon rainfall and crop data covering the seventy-two years from 1839 to 1910, and price data for the period 1870–1910.

In the light of present knowledge, therefore, we are justified in conceiving cyclical fluctuations to be rhythmic, but we are not justified in postulating periodicity. That is, cyclical fluctuations, *per se*, are not distinguishable from irregular fluctuations. It is certainly impossible, in general, for the statistician to isolate these two types of fluctuations from each other. It is not impossible, however, to isolate the two combined from secular trend and seasonal variation, since independent measurements of the last named fluctuations have been made.

The method adopted of correcting the original data for secular trend and seasonal variation was as follows: (*a*) the monthly ordinates of the line of secular trend were computed; (*b*) these ordinates were multiplied by the indices of seasonal variation; (*c*) the resulting products were subtracted from the corresponding items of the original series; (*d*) the resulting deviations, plus or minus, were expressed as percentages of the secular trend.[1]

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[1] In mathematical symbols the operation would be as follows: Let the original series beginning with January, be x_1, x_2, x_3 . . . x_n, the ordinates of secular trend be o_1, o_2, o_3 . . . o_n, and the adjusted indices of seasonal variation for twelve months be s_1, s_2, s_3 . . . s_{12} per cent, respectively. Then the items corrected for secular trend and seasonal variation are:

$$\frac{x_1 - s_1o_1}{o_1},\ \frac{x_2 - s_2o_2}{o_2},\ \frac{x_3 - s_3o_3}{o_5} \ldots \frac{x_{12} - s_{12}o_{12}}{o_{12}},$$

$$\frac{x_{13} - s_1o_{13}}{o_{13}},\ \frac{x_{14} - s_2o_{14}}{o_{14}} \ldots\ldots\ldots\ldots\ldots$$

$$\text{or, } \frac{x_1}{o_1} - s_1,\ \frac{x_2}{o_2} - s_2,\ \frac{x_3}{o_3} - s_3 \cdots \text{etc.}$$

The percentage deviations obtained for the several series by the process just described have a wide range of distribution for some series and a narrow range for others. For instance, during the period 1903–16 New York bank clearings ranged from −49 per cent to +64 per cent; outside bank clearings, from −23 per cent to +33 per cent; and the rate of interest on ten railway bonds, from −4 per cent to +11 per cent. This difference in range means that a deviation of +10 per cent in one series indicates quite a different thing from what is indicated by a similar percentage deviation in another series. That is, in *judging* the meaning of fluctuations of different series, percentages are not proper units to use. The problem, therefore, is to express the deviations of different series in comparable terms. What is a " normal " fluctuation for each series ? To answer this question a unit must be constructed for each series, which unit must depend upon the dispersion of percentage deviations in such series, so that the greater the dispersion the greater the unit. The range of the items is not a good measure of dispersion because it does not depend upon the distribution of the items between the maximum and the minimum. We need a measure of dispersion that, like an average, depends upon all the items of the series. Of various measures which have been used by statisticians, the *standard deviation* is, without question, the most important and satisfactory. " The standard deviation is the square root of the arithmetic mean of the squares of all deviations, deviations being measured from the arithmetic mean of the observations."[1] In the present instance the "observations" are percentage deviations from the corrected secular trend. Since the arithmetic average of the positive and negative percentage deviations is approximately zero,[2] the standard deviation is the square root of the arithmetic mean of the squares of the items we are using. In comparing the significance of fluctuations of different series we shall express the percentage deviations in terms of the respective standard deviations as units. The standard deviations, 1903–16, are given in Table F.

Graphs of the percentage deviations, 1903–18, in terms of the standard deviations, 1903–16, as units, are given in Charts 101 to 114. These charts picture the fluctuation corrected for (*a*) secular trend and (*b*) seasonal variation, and expressed (*c*) in units appropriate for the comparison of different series.

The first part of our task, the development of a method of analyzing each series by itself, has been completed. A summary of the method, the sources and the nature of the data used, conclusions resulting from the application of the method to selected series, tables giving all essential figures, and charts presenting the results graphically — these form the subject matter of Part II.

TABLE F — STANDARD DEVIATIONS OF THE RELATIVE DEVIATIONS OF THE ORIGINAL SERIES FROM THE LINE OF SECULAR TREND CORRECTED FOR SEASONAL VARIATION *

Name of Series	Standard Deviation
1. New York Clearings	20.3
2. Production of Pig Iron	19.15
3. Outside Clearings	8.62
4. Bradstreet's Prices	3.68
5. Imports	11.91
6. Building Permits	20.4
7. Railroad Gross Earnings	6.07
8. Shares Traded	49.6
9. Unfilled Orders U. S. S. C.	†
10. Tonnage Entered	†
11. Business Failures (Bradstreet)	13.55
12. Rate on 10 Railroad Bonds	2.82
13. Rate on 4–6 Months Paper	16.46
14. Rate on 60–90 Day Paper	19.66
15. Rate on Call Loans	†

* These are the units used in Charts 101–115 to secure comparable graphs. † Not computed.

5. Remaining Problems of Method and Interpretation

Having developed a method of correcting each series for the elements not significant of business conditions, and having applied that method to individual series, certain important and difficult problems remain to be considered. Indeed, the separate analysis and correction of each series by itself is but one step in a series of three which must be made before statistical data may properly be used as indices of business conditions. The corrected series having been interpreted individually, the second step is to construct a method for studying them in relation to each other and to the economic history of the period covered. Such a comparative study will enable one to make generalizations, based on a number of series, concerning the business conditions of a *past* period. As has been said in the preceding discussion, however, the value of generalizations based on past data depends upon the applicability of such generalizations to the present. The aim of the entire analysis is to evolve a method whereby current statistics may be used as a guide to current business conditions. Having established a means of correcting individual series, therefore, and having, further, developed a method for comparative study of fluctuations in different series, there will remain a third requirement. If the data of the past are to be used as a clue to the present, we must show that economic organization and business usage have not so altered as to change the significance of the data.

The present number of the Review, then, is devoted to a treatment of the first of the three problems which,

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[1] For a discussion of this subject see Yule's *Theory of Statistics*, chap. 8. If x represents deviations from the arithmetic mean, n represents the number of items, and σ the standard deviation we have

$$\sigma^2 = \frac{1}{n}\Sigma(x^2).$$

If ξ represents the deviations from an arbitrary quantity, and d represents the difference between the arithmetic mean and the arbitrary quantity, we have

$$\sigma^2 = \frac{1}{n}\Sigma(\xi^2) + d^2.$$

[2] For instance in the case of imports of merchandise the algebraic sum of the percentage deviations was + 24 and the absolute sum was 1510. The standard deviation of 11.91, computed on the assumption that the algebraic sum is zero, is not altered by correcting for the slight discrepancy.